CYLINDER APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a cylinder apparatus which has a cushion mechanism capable of changing the displacement speed of a piston around an end of displacement thereof. The piston is displaceable in the axial direction in a cylinder body.

Description of the Related Art:

A cylinder apparatus driven by a pressure fluid is used as a driving mechanism for transporting and positioning a workpiece or driving a variety of industrial machines.

As shown in FIG. 8, the cylinder apparatus comprises a piston 2 which is provided displaceably in a cylinder body 1. An elongate piston rod 3 is connected to the piston 2. A head cover 4a and a rod cover 4b are connected to ends of the cylinder body 1, and the ends of the cylinder body 1 are closed thereby. Pressure fluid ports 5a, 5b, through which the pressure fluid is supplied and discharged, are formed in the head cover 4a and the rod cover 4b, respectively. The piston 2 is displaced in the axial direction by the pressure fluid supplied from the pressure fluid ports 5a, 5b to a cylinder chamber 6 in the cylinder body 1.

Cushion valves 7a, 7b are provided for the head cover 4a and the rod cover 4b, each of which controls the flow rate of the pressure fluid discharged from the cylinder

chamber 6.

The head cover 4a and the rod cover 4b are provided with check valves 8a, 8b which are disposed in the vicinity of the cushion valves 7a, 7b.

First communication passages 9a are formed so that the cylinder chambers 6 communicate with holes in which the cushion valves 7a, 7b are provided. The holes communicate with the interiors of the head cover 4a and the rod cover 4b into which the piston rod 3 is inserted.

Second communication passages 9b are formed so that the cylinder chambers 6 communicate with holes in which the check valves 8a, 8b are provided. The holes communicate with the interiors of the head cover 4a and the rod cover 4b into which the piston rod 3 is inserted.

The cushion valves 7a, 7b can be screwed by the screw sections with respect to the head cover 4a and the rod cover 4b. When the cushion valves 7a, 7b are screwed, the cushion valves 7a, 7b are displaced in the direction substantially perpendicular to the axis of the cylinder body 1. The cross-sectional areas of the flow passages for the pressure fluid flowing through the first communication passages 9a are changed by the ends of the cushion valves 7a, 7b when the cushion valves 7a, 7b are displaced to adjust the flow rates of the pressure fluid to be discharged to the outside from the pressure fluid ports 5a, 5b via the first communication passages 9a.

When the pressure fluid is supplied from one pressure

fluid port 5b near the rod cover 4b, for example, the piston 2 is displaced toward the head cover 4a together with the piston rod 3. During this process, the pressure fluid remaining in the cylinder chamber 6 disposed near the head cover 4a is discharged to the outside from the pressure fluid port 5a via the interior of the head cover 4a into which the end of the piston rod 3 is inserted when the piston 2 is displaced.

When the end of the piston rod 3 is inserted into the head cover 4a, the pressure fluid is discharged from the pressure fluid port 5a via the first communication passage 9a. The displacement speed of the piston 2 is decelerated by adjusting the discharge amounts of the pressure fluid flowing through the first communication passages 9a by screwing the cushion valves 7a, 7b as described above (see, for example, "JIS Handbook", JIS B 8377-1981 (p. 538, FIG. 2)).

In the case of the cylinder apparatus disclosed in "JIS Handbook", JIS B 8377-1981 (p. 538, FIG. 2), the flow rates of the pressure fluid to be discharged from the first communication passages 9a are adjusted by screwing the cushion valves 7a, 7b provided in the head cover 4a and the rod cover 4b, respectively, to change the displacement speed of the piston 2 which is displaced in the cylinder body 1. Thus, the piston 2 is prevented from the collision with the head cover 4a or the rod cover 4b by cushioning.

However, in the conventional apparatus, when the

displacement speed of the piston 2 is adjusted by using the cushion valves 7a, 7b, the cushion valves 7a, 7b are displaced in the axial direction. Therefore, for example, the cushion valves 7a, 7b are recessed by predetermined depths from the side surface of the cylinder body 1. When the cylinder apparatus is used in an environment in which liquid or the like is used in the vicinity of the cylinder apparatus, the liquid and the dust or the like are remained in the holes in which the cushion valves 7a, 7b are installed.

SUMMARY OF THE INVENTION

A general object of the present invention is to provide a cylinder apparatus which makes it possible to prevent a rotatable member from being recessed with respect to a cylinder body when the displacement speed is adjusted around an end of displacement of a piston by using the rotatable member and an adjusting member installed to a cover member and/or the cylinder body.

A principal object of the present invention is to provide a cylinder apparatus which makes it possible to avoid any liquid pool or the like on an outer surface of a cylinder body even when the cylinder apparatus is used in an environment in which liquid or the like is used.

The above and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the

accompanying drawings in which a preferred embodiment of the present invention is shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view illustrating a cylinder apparatus according to an embodiment of the present invention;

FIG. 2 is, with partial omission, a longitudinal sectional view illustrating the cylinder apparatus shown in FIG. 1;

FIG. 3 is a partial magnified longitudinal sectional view mainly illustrating a throttle valve of the cylinder apparatus shown in FIG. 2;

FIG. 4 is a magnified exploded perspective view illustrating the throttle valve shown in FIG. 2;

FIG. 5 is a partial magnified longitudinal sectional view showing that a piston of the cylinder apparatus shown in FIG. 2 is displaced toward a rod cover and abuts against the rod cover;

FIG. 6 is a partial magnified longitudinal sectional view showing that the piston of the cylinder apparatus shown in FIG. 5 is slightly displaced toward a head cover;

FIG. 7 is a partial magnified longitudinal sectional view showing that the piston of the cylinder apparatus shown in FIG. 5 abuts against the head cover; and

FIG. 8 is, with partial omission, a longitudinal sectional view illustrating a conventional cylinder

apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIG. 1, reference numeral 10 indicates a cylinder apparatus according to an embodiment of the present invention.

The cylinder apparatus 10 has a cylindrical shape. The cylinder apparatus 10 comprises a cylinder tube (cylinder body) 14 in which a first port 12a and a second port 12b are formed to supply and discharge the pressure fluid, a head cover (cover member) 16 which is secured to one end of the cylinder tube 14, a rod cover (cover member) 18 which is secured to the other end of the cylinder tube 14, a piston 20 (see FIG. 2) which is displaceable in the axial direction in the cylinder tube 14, a piston rod 22 which is connected penetratingly through the piston 20, and a pair of throttle valves 28a, 28b which function as cushion mechanisms for adjusting the displacement speeds of the piston 20 around the ends of displacement.

The cylinder tube 14 is not limited to the structure in which the head cover 16 and the rod cover 18 are secured to the ends of the cylinder tube 14. One end thereof may be closed by a cylinder tube, and only the other end thereof may be closed by a cover member or the like.

The first port 12a and the second port 12b are formed on the upper surface of the cylinder tube 14. The pressure fluid is supplied from an unillustrated pressure fluid

supply source to the first port 12a or the second port 12b, and the pressure fluid contained in the cylinder tube 14 is discharged from the first port 12a or the second port 12b. The first and second ports 12a, 12b are separated from each other by a predetermined distance, and are arranged on a straight line. First and second installation holes 26a, 26b (see FIG. 2) are separated from the first port 12a and the second port 12b by predetermined distances, respectively. The first and second ports 12a, 12b are not limited to the structure in which they are arranged on the straight line.

The first and second installation holes 26a, 26b are arranged on the straight line with respect to the first port 12a and the second port 12b. The throttle valves 28a, 28b are arranged in the first and second installation holes 26a, 26b, respectively. The first and second installation holes 26a, 26b, are not limited to the structure in which they are arranged on the straight line. Similarly, the throttle valves 28a, 28b, which are installed to the first and second installation holes 26a, 26b, are also not limited to the structure in which they are arranged on the straight line.

Further, the throttle valves 28a, 28b are not limited to the structure in which they are installed to the head cover 16 and the rod cover 18. Installation holes may be formed in the cylinder tube 14, and the throttle valves 28a, 28b may be installed thereto.

Each of the head cover 16 and the rod cover 18 is installed to the end of the cylinder tube 14 by attachment

bolts 32 which are inserted into holes 30 formed at four corners thereof. A rod guide 34 is screwed in the end of the rod cover 18, and supports the piston rod 22.

As shown in FIG. 2, a first cylinder chamber 36 is formed between the head cover 16 and one end of the piston 20 in the cylinder tube 14, and a second cylinder chamber 38 is formed between the rod cover 18 and the other end of the piston 20. The first cylinder chamber 36 communicates with the first port 12a via a first communication chamber 40 in the head cover 16. The second cylinder chamber 38 communicates with the second port 12b via a second communication chamber 42.

The first end of the piston rod 22 is inserted into the first communication chamber 40. The outer circumferential surface of the piston rod 22 is surrounded by a first rod packing 44 which is installed to an annular groove formed on the inner circumferential surface of the first communication chamber 40. A lip section 46 is formed on the inner circumferential side of the first rod packing 44. The lip section 46 is inclined by a predetermined angle toward the first cylinder chamber 36. The inner circumferential surface of the lip section 46 abuts against the outer circumferential surface of the piston rod 22.

Accordingly, the pressure fluid from the first port 12a flows into the first cylinder chamber 36 via the first communication chamber 40. The lip section 46 prevents the pressure fluid from flowing from the first cylinder chamber

36 toward the first communication chamber 40.

The second end of the piston rod 22 is inserted into the second communication chamber 42. The outer circumferential surface of the piston rod 22 is surrounded by a second rod packing 48 which is installed to an annular groove formed on the inner circumferential surface of the second communication chamber 42. A lip section 46 is formed on the inner circumferential side of the second rod packing 48. The lip section 46 is inclined by a predetermined angle toward the second cylinder chamber 38. The inner circumferential surface of the lip section 46 abuts against the outer circumferential surface of the piston rod 22.

Accordingly, the pressure fluid from the second port 12b flows into the second cylinder chamber 38 via the second communication chamber 42. The lip section 46 prevents the pressure fluid from flowing from the second cylinder chamber 38 toward the second communication chamber 42.

As shown in FIG. 3, each of the first and second installation holes 26a, 26b includes a first hole section 50 which is formed on the surface of the cylinder tube 14, a second hole section 52 which is formed under the first hole section 50 while being diametrally reduced, a female thread section 54 which is formed under the second hole section 52 while being slightly diametrally reduced and which has a thread on the inner circumferential surface, and a communicating section 56 which is formed under the female thread section 54 and which communicates with first bypass

passages 58a, 58b and second bypass passages 60a, 60b as described later on.

As shown in FIG. 2, the first and second installation holes 26a, 26b are formed with the first bypass passages 58a, 58b which extend substantially in parallel to the axis of the piston rod 22 from the inner circumferential surface thereof, and the second bypass passages 60a, 60b which extend substantially perpendicularly to the axis of the piston rod 22 from the lower end of each of the first and second installation holes 26a, 26b.

That is, the first and second installation holes 26a, 26b communicates with the first and second cylinder chambers 36, 36 via the first bypass passages 58a, 58b, respectively; and the first and second installation holes 26a, 26b communicates with the first and second communication chambers 40, 42 via the second bypass passages 60a, 60b, respectively.

The rod guide 34 is integrally connected by being screwed with the rod cover 18 at one end thereof. A hole is formed in the rod guide 34, through which the second end of the piston rod 22 is inserted displaceably in the axial direction.

A seal member 62 is installed to an annular groove formed on the inner circumferential surface of the rod guide 34. The seal member 62 abuts against the outer circumferential surface of the piston rod 22. Therefore, air-tightness is preferably retained for the pressure fluid

contained in the cylinder tube 14.

A scraper 64 is installed to an annular groove formed at the other end of the rod guide 34. The scraper 64 prevents the dust or the like adhered when the piston rod 22 is exposed from the cylinder apparatus 10 from entering the cylinder tube 14.

The pair of throttle valves 28a, 28b are arranged in the first and second installation holes 26a, 26b formed at the upper surface of the cylinder tube 14, respectively, and function as the cushion mechanisms.

As shown in FIGS. 3 and 4, each of the throttle valves 28a, 28b comprises a rotatable member 66 which is arranged at an upper position and which has a substantially T-shaped cross section, a needle (adjusting member) 68 which has an upper end to be engaged with a substantially central portion of the rotatable member 66 and which has a lower end in a tapered shape, a ring-shaped covering member 70 which is installed between the inner circumferential surface of each of the first and second installation holes 26a, 26b and the outer circumferential surface of the rotatable member 66, and a stopper ring (fastening member) 72 which has a substantially C-shaped cross section and which is engageable with an outer circumferential portion of the needle 68.

The rotatable member 66 is arranged in the first hole section 50 of each of the first and second installation holes 26a, 26b. As shown in FIG. 4, the rotatable member 66 comprises a substantially columnar holding section 76 which

is formed with cutout grooves 74 by predetermined depths on the outer circumferential surface, a flange section 78 which is formed under the holding section 76 and which is expanded radially outwardly, and an engaging recess 80 with which an engaging projection 82 of the needle 68 is engageable as described later on.

Four cutout grooves 74 are formed at intervals of about 90° circumferentially at upper portions of the holding section 76. When the cutout grooves 74 are gripped with an unillustrated tool or the like, it is possible to preferably rotate the rotatable member 66.

As shown in FIG. 3, the outer circumferential diameter of the flange section 78 is substantially equal to the inner circumferential diameter of the first hole section 50. When the rotatable member 66 is installed in the first hole section 50, the lower surface of the flange section 78 abuts against the bottom surface of the first hole section 50. When the stopper ring 72 is installed to an annular groove formed on the inner circumferential surface of the first hole section 50, the upward displacement of the rotatable member 66 is prevented thereby.

Accordingly, the rotatable member 66 is held between the bottom surface of the first hole section 50 and the stopper ring 72. Therefore, the displacement of the rotatable member 66 in the axial direction (direction of the arrow A or B shown in FIG. 3) is prevented. Each of the throttle valves 28a, 28b including the rotatable member 66

is prevented from disengagement to the outside from the inside of each of the first and second installation holes 26a, 26b.

As shown in FIG. 4, the stopper ring 72 has a substantially C-shaped cross section, and it is installed to the annular groove of the first hole section 50 by the repulsive force thereof (see FIG. 3).

As shown in FIG. 3, the engaging recess 80 is formed at a substantially central portion of the rotatable member 66. The engaging recess 80 is formed while being recessed by a predetermined depth toward the holding section 76 from the end surface of the flange section 78. The engaging recess 80 has a substantially rectangular shape corresponding to the shape of the engaging projection 82. The engaging projection 82 of the needle 68 is inserted displaceably in the axial direction into the engaging recess 80.

The engaging recess 80 has a predetermined depth. Thus, even when the needle 68 is displaced to the uppermost position, there is a predetermined clearance between the upper end of the engaging projection 82 of the needle 68 and the upper surface of the engaging recess 80.

As shown in FIGS. 3 and 4, the needle 68 comprises the substantially rectangular engaging projection 82 which protrudes upwardly by a predetermined length, a guide section 84 which is formed under the engaging projection 82 and which has its outer circumferential surface to abut against the inner circumferential surface of each of the

first and second installation holes 26a, 26b, a screw section 86 which has a thread on the outer circumferential portion and which is engageable with the female thread section 54 of each of the first and second installation holes 26a, 26b, a shaft section 88 which is diametrally reduced radially inwardly as compared with the screw section 86, a first tapered section 90 which is diametrally reduced stepwise downwardly from the shaft section 88, and a second tapered section 92 which is further diametrally reduced as compared with the first tapered section 90. A seal member 94 is installed to an annular groove which is formed between the guide section 84 and the screw section 86.

The engaging projection 82 is inserted into the engaging recess 80 which is formed corresponding to the outer shape of the engaging projection 82. Therefore, when the rotatable member 66 is rotated, the rotatable member 66 and the needle 68 are rotated integrally since the engaging projection 82 and the engaging recess 80 are engaged.

The guide section 84 is formed so that the outer circumferential surface thereof abuts against the inner circumferential surface of each of the first and second installation holes 26a, 26b. Therefore, the needle 68 slides in the axial direction in each of the first and second installation holes 26a, 26b as guided by the guide section 84. During this movement, air-tightness is reliably retained in each of the first and second installation holes 26a, 26b by the seal member 94 installed to the annular

groove.

The screw section 86 having the thread on the outer circumferential surface is formed at the substantially central portion of the needle 68 in the axial direction. The screw section 86 is screwed with the female thread section 54 of each of the first and second installation holes 26a, 26b. That is, when the needle 68 is rotated, the needle 68 is displaced in the axial direction in each of the first and second installation holes 26a, 26b by the screwing of the screw section 86.

The first tapered section 90 is provided under the screw section 86 via the shaft section 88 which is reduced radially inwardly as compared with the screw section 86. The first tapered section 90 is diametrally reduced gradually in the downward direction.

The second tapered section 92 is further diametrally reduced as compared with the first tapered section 90. The second tapered section 92 is arranged so that the second tapered section 92 is opposed to the opening of each of the second bypass passages 60a, 60b (see FIG. 3).

That is, the cross-sectional area of the flow passage at the opening of the second bypass passage 60 can be changed by the tapered surface of the second tapered section 92 when the needle 68 is displaced in the axial direction. Accordingly, when the needle 68 is displaced in the axial direction, it is possible to control the flow rate of the pressure fluid flowing through each of the first bypass

passages 58a, 58b and the second bypass passages 60a, 60b.

The annular covering member 70 is installed to the upper portion of the first hole section 50 of each of the first and second installation holes 26a, 26b so that the holding section 76 of the rotatable member 66 is surrounded thereby. The covering member 70 is formed of an elastic material such as nitrile rubber (NBR). An annular ring member 96 of a metal material is contained in the covering member 70 (see FIG. 3).

That is, when the ring member 96 is provided in the covering member 70, the rigidity is increased at the portion of installation to the outer circumference of the holding section 76. Thus, the rotatable member 66 and each of the first and second installation holes 26a, 26b are sealed more reliably.

The cylinder apparatus 10 according to the embodiment of the present invention is basically constructed as described above. Next, its operation, function, and effect will be explained.

The pressure fluid (for example, compressed air) is supplied from the unillustrated pressure fluid supply source to the first port 12a. As shown in FIG. 2, the pressure fluid, which is supplied to the first port 12a, flows into the first cylinder chamber 36 via the first communication chamber 40. The piston 20 arranged in the first cylinder chamber 36 is pressed toward the rod cover 18. In this situation, the second port 12b is opened to the atmospheric

air. Therefore, the pressure fluid in the second cylinder chamber 38 is discharged to the outside from the second port 12b via the second communication chamber 42. The end surface of the piston 20 abuts against the end surface of the rod cover 18, and the piston 20 stops at one end of displacement.

When the piston 20, which has been displaced toward the rod cover 18, is displaced toward the head cover 16 reversely to the above, the first port 12a is opened to the atmospheric air, and the pressure fluid is supplied from the second port 12b. The pressure fluid supplied to the second port 12b flows into the second cylinder chamber 38 via the second communication chamber 42. The piston 20 arranged in the second cylinder chamber 38 is pressed toward the head cover 16. In this situation, the first port 12a is opened to the atmospheric air. Therefore, the pressure fluid in the first cylinder chamber 36 is discharged to the outside from the first port 12a via the first communication chamber 40. The end surface of the piston 20 abuts against the end surface of the head cover 16, and the piston 20 stops at the other end of displacement.

Next, an explanation will be made about a process in which cushioning is exhibited by adjusting the displacement speed of the piston 20 displaceable in the axial direction in the cylinder tube 14 by using the throttle valve 28a, 28b. The explanation will now be made about a procedure in which the throttle valve 28a, which is installed to the

first installation hole 26a, is adjusted to change the displacement speed when the piston 20 is displaced in the direction toward the head cover 16.

At first, the cutout grooves 74 of the holding section 76 of the throttle valve 28a are gripped by an unillustrated tool or the like to rotate the rotatable member 66 in the circumferential direction. The needle 68 is rotated by the engaging projection 82 engaged with the engaging recess 80 of the rotatable member 66 when the rotatable member 66 is rotated. Accordingly, the needle 68 is displaced in the axial direction by screwing action, because the needle 68 is screwed with the female thread section 54 of the first installation hole 26a by the screw section 86.

During this process, as the needle 68 is displaced in the axial direction, the engaging projection 82 is displaced in the axial direction in the engaging recess 80. In this situation, the rotatable member 66 is not displaced in the axial direction, because the rotatable member 66 is held between the stopper ring 72 and the bottom surface of the first hole section 50. Therefore, the amount of protrusion of the rotatable member 66 from the upper surface of the cylinder tube 14 is always constant.

That is, the depth of the engaging recess 80 of the rotatable member 66 is previously set. Thus, the upper end of the engaging projection 82 does not contact the upper surface of the engaging recess 80 even when the needle 68 is displaced upwardly in the axial direction. Therefore, the

rotatable member 66 is not pressed upwardly when the needle 68 is displaced in the axial direction.

During this process, for example, when it is intended to decrease the displacement speed of the piston 20, the rotatable member 66 is screwed so that the needle 68 is displaced in the direction toward the center of the cylinder tube 14 (direction of the arrow A) as shown in FIG. 3. When it is intended to increase the displacement speed of the piston 20 reversely to the above, the rotatable member 66 is screwed so that the needle 68 is displaced in the direction to separate from the center of the cylinder tube 14 (direction of the arrow B).

As a result, the distance between the opening of the second bypass passage 60a and the second tapered section 92 of the needle 68 is changed. That is, the clearance can be changed between the opening of the second bypass passage 60a and the second tapered section 92, and thus it is possible to adjust the flow rate of the pressure fluid flowing through the first and second bypass passages 58a, 60a.

In other words, it is possible to adjust the flow rate of the pressure fluid to be discharged from the first cylinder chamber 36 via the first port 12a.

When the throttle valve 28a, which functions as the cushion mechanism, is used to arbitrarily set the flow rate of the pressure fluid flowing through the first and second bypass passages 58a, 60a of the first installation hole 26a, the pressure fluid from the second port 12b flows into the

second cylinder chamber 38 via the second communication chamber 42 as shown in FIG. 2, and the piston 20 is pressed toward the head cover 16.

During this process, as shown in FIG. 5, the pressure fluid in the first cylinder chamber 36 is discharged to the outside from the first port 12a via the first communication chamber 40 when the piston 20 is displaced. At the same time, the pressure fluid flows into the communicating section 56 via the first bypass passage 58a communicated with the first cylinder chamber 36. The pressure fluid flows into the first communication chamber 40 via the clearance between the second tapered section 92 of the needle 68 and the second bypass passage 60a, and the pressure fluid is discharged to the outside from the first port 12a via the first communication chamber 40.

That is, as shown in FIG. 5, when the pressure fluid in the first cylinder chamber 36 is discharged in accordance with the displacement of the piston 20, the pressure fluid is directly discharged via the first communication chamber 40, and the pressure fluid is discharged from the first port 12a via the first and second bypass passages 58a, 60a arranged with the throttle valve 28a.

Subsequently, when the pressure fluid further flows into the second cylinder chamber 38 from the second port 12b, the piston 20 is further displaced toward the head cover 16 by the pressing action of the pressure fluid as shown in FIG. 6. One end of the piston rod 22 is inserted

into the first communication chamber 40.

In this situation, one end of the piston rod 22 is inserted into the first communication chamber 40, and the outer circumferential surface thereof is surrounded by the first rod packing 44. Therefore, the pressure fluid in the first cylinder chamber 36 is prevented from flowing directly to the first communication chamber 40.

That is, the pressure fluid in the first cylinder chamber 36 is prevented from flowing into the first communication chamber 40 by the sealing of the first rod packing 44. Therefore, the pressure fluid in the first cylinder chamber 36 flows to the communicating section 56 of the first installation hole 26a via the first bypass passage 58a. The pressure fluid flows to the second bypass passage 60a via the clearance between the second tapered section 92 of the needle 68 and the opening of the second bypass passage 60a. The pressure fluid passes through the second bypass passage 60a, and the pressure fluid is discharged to the outside from the second port 12b via the first communication chamber 40.

During this process, as shown in FIG. 5, the flow rate of the pressure fluid is decreased when the pressure fluid in the first cylinder chamber 36 is discharged to the outside from the first port 12a via the first and second bypass passages 58a, 60a, as compared with the case in which the pressure fluid in the first cylinder chamber 36 directly flows to the first communication chamber 40 to be discharged

to the outside from the first port 12a.

In other words, the pressure fluid remaining in the first cylinder chamber 36 generates displacement resistance when the piston 20 is displaced toward the head cover 16. Accordingly, the displacement speed of the piston 20 is lowered.

As a result, the displacement speed of the piston 20 can be gradually decreased before the piston 20 arrives at the end of displacement on the side of the head cover 16. Therefore, it is possible to absorb the shock when the piston 20 is displaced toward the head cover 16 and the piston 20 arrives at the head cover 16 (see FIG. 7).

As described above, in the embodiment of the present invention, the throttle valves 28a, 28b are installed to the first and second installation holes 26a, 26b of the head cover 16 and the rod cover 18. The rotatable member 66 of each of the throttle valves 28a, 28b is fastened by the stopper ring 72 so that the rotatable member 66 is not displaced in the axial direction.

When the displacement speed of the piston 20 around the end of displacement is adjusted by using the throttle valve 28a, 28b, the rotatable member 66 is rotated to displace the needle 68 in the axial direction, and thus the engaging projection 82 of the needle 68 is displaced in the axial direction in the engaging recess 80 of the rotatable member 66. In this situation, the depth of the engaging recess 80 has a depth such that the upper end of the engaging

projection 82 does not contact the upper surface of the engaging recess 80 when the engaging projection 82 is displaced in the upward direction. Therefore, the rotatable member 66 is not pressed upwardly when the needle 68 is displaced in the axial direction.

Therefore, when the needle 68 engaged with the rotatable member 66 is displaced in the axial direction, the displacement of the needle 68 in the axial direction is absorbed by the engaging recess 80, and the rotatable member 66 is not displaced in the axial direction.

As a result, even when the rotatable member 66 is rotated to control the flow rate of the pressure fluid flowing through each of the first bypass passages 58a, 58b and the second bypass passages 60a, 60b, the amount of protrusion of the throttle valve 28a, 28b from the head cover 16 and the rod cover 18 is not changed, but is always constant. Therefore, even when the displacement speed of the piston 20 is adjusted by using the throttle valves 28a, 28b, the outer shape of the cylinder apparatus 10 is not changed.

Further, the displacement of the rotatable member 66 in the axial direction is preferably prevented by the stopper ring 72. The rotatable member 66 is not recessed from the upper surface of each of the head cover 16 and the rod cover 18 to which the rotatable member 66 is installed. Therefore, even when liquid or the like is used in the vicinity of the cylinder apparatus 10, the liquid and the

dust or the like are prevented from being collected in the first and second installation holes 26a, 26b installed with the throttle valves 28a, 28b.